

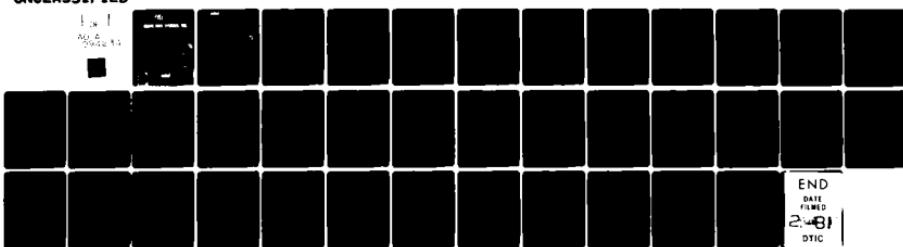
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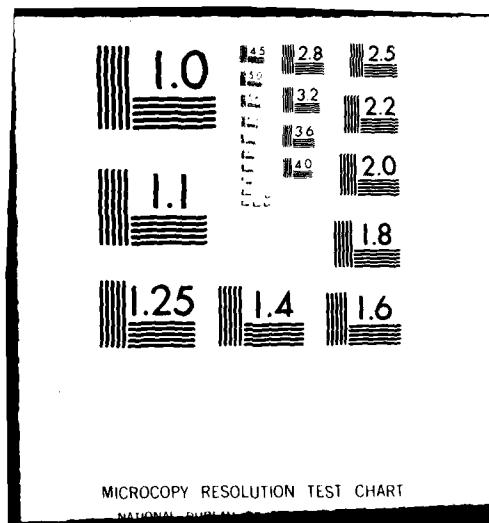
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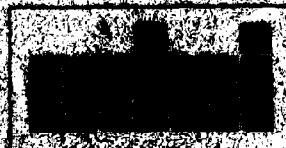
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## FOREWORD

This document is a Technical Task Report for Contract No. N00014-73-C-0131 for the Office of Naval Research. The report summarizes the work performed in fulfilling contract objectives.

Ocean Data Systems, Inc. is indebted to Mr. R. Plum, MASWSPO for his efforts in securing the data and information required in the performance of the task effort. Additionally, ODSI wishes to acknowledge the support and cooperation of Messrs. George Brown and Dick D'Urso of the Naval Underwater Systems Center, Messrs. Paul Tiedman and Barry Chapman of the Naval Ship Systems Command, Messrs. Donald Mudd and Robert Lawrence of the Naval Electric Laboratory Center, Dr. P. R. Tatro and Mr. C. W. Spofford of the Acoustic Environment Support Detachment, and Messrs. Tom Russell and Jerry Bradshaw of Raytheon.

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ABSTRACT

→ This report analyzes the SIMAS and FLIT acoustic performance systems, under development at the Naval Underwater Systems Center, Newport, Rhode Island, focusing on the degree of commonality of conceptual approach and compatibility of computed results. Where an operational basis for comparison is required, reference is to the ICAPS system currently installed aboard the USS Kitty Hawk (CV-63) and to the Navy Tactical Data System (NTDS). It is concluded that the constraints imposed by existing on-board computer environments and associated administrative procedures preclude the attainment of an at-sea SIMAS capability within a reasonably short timeframe, except where extra Q-20 computers are available outside the NTDS system, and that external design constraints imposed on the FLIT developers have precluded the incorporation of compatible transmission loss physics into this model.

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## I. INTRODUCTION

There are currently a large number of acoustic performance prediction systems, both shore-based and at-sea, which are in various stages of development and operational use. Many of these systems have structural similarities which are a direct consequence of their related overall objectives and the nature of the common problems being solved. Also, however, many differences exist among these systems.

Some of the differences among the systems are a direct consequence of the differences in the environments within which each of the systems is to operate or for reasons of historical development. Other differences exist because different methods are used to calculate intermediate values such as transmission loss or because some of the systems consider more variables in their calculations than others which may choose to estimate the effects of such variables by using averages or simple distributions. Further, differences may also occur because of variations in the sources or types of input data and whether that data has been pre-processed in any way such as elimination of exceptional points, smoothing, or by subjecting such input data to range tests and error detection.

In the course of the task effort reported herein, the SIMAS and FLIT at-sea performance prediction systems were

analyzed from the viewpoint of ascertaining the degree to which a commonality of conceptual approach and compatibility of comparable computed results could be fostered. The systems are currently under development at the Naval Underwater Systems Center (NUSC), Newport, Rhode Island.

The primary emphasis was placed on the determination of the computational and environmental resources required, and on the computational and data utilization techniques employed, and the implications of these factors for standardization of Navy acoustic performance prediction systems. ODSI's role in the performance of these analyses was primarily focused towards programmatic implementation rather than towards the physics modeled by the systems. Navy organizations such as the Acoustic Environmental Support Division were to assess the acoustic and environmental goodness of their constituent elements for the Government's Scientific Officer.

Section II of this report presents the ODSI review of FLIT based on existing documentation of the system; Appendix A presents a memorandum prepared by AESD addressing the FLIT Program. Sections III through VI outline the objectives and status of SIMAS, its compatibility with existing systems and prospects for an at-sea operational capability. Material contained in these sections has been reported on in earlier ODSI Technical Task Reports.

## **II. REVIEW OF THE FLIT SYSTEM**

The FLIT effort has been directed toward the determination of the compatibility of this system with other existing Navy propagation and performance estimation models. As a first step in this effort, a review of the existing documentation of FLIT was initiated. The Scientific Officer assigned the review of the acoustic and sonar system performance considerations to the Acoustic Environmental Support Detachment (AESD), while Ocean Data Systems, Inc. was directed to review the programming and systems analysis aspects. This section of this task report summarizes the results of the ODSI review.

The specific document made available for assessment is the "MPS Ray Path Trace Submode Design and Performance Specifications", which presents a detailed description of the objectives of each of eleven software modules of MPS. These modules are organized into four broad categories as follows:

### System Monitor and Control

- PSPS, the overall MPS software supervisor
- RTSM, which controls the selection of MPS modes

### Data Entry and Display

- RTDE, controlling the interactive data entry from the system console
- RTVP, handling the entry and display of the sound velocity profile

- RTTU, handling the entry of data for table updating

#### Ray Tracing and Display

- RTRD, displaying the ray paths traced by UPS
- RTRP, which generates the ray paths to be displayed
- RTRC, which performs the actual ray trace for a single ray cycle

#### Functional Evaluation

- RTCT, which computes water temperature as a function of sonic velocity, salinity, depth, and latitude
- RTCV, which computes sonic velocity as a function of temperature, salinity, depth, and latitude
- RTBL, which computes bottom-bounce losses as a function of incidence angle and bottom class
- RTSL, which computes surface-reflection losses as a function of frequency and sea state

Before commenting individually on these models, a word about the overall design is in order. The software design appears to be well thought-out and modularized into manageable routines whose interactions can be kept to a minimum, thus easing the software programming, checkout, and maintenance tasks. With one significant exception -- the lack of introductory

material spelling out the software structure, hardware constraints, nomenclature employed -- the documentation is detailed, comprehensive and well-organized. Perhaps such an introduction exists elsewhere; if so, it should be included whenever the current material is distributed; if not, one should be prepared to ease the burden of becoming acquainted with the material presented.

The flowcharts are complete, within each module, written at an appropriate level of detail. Again, however, a significant lack is that of an over-all, high-level flow showing the interactions of each of the modules, and how specific hardware features -- interrupts, data entry keys, shaft encoders, etc. -- are interfaced. Similarly, the means by which data values are passed between modules is not detailed; this is a function of the programming language used and the software system functions available to support the implementation of the language, neither of which are referenced in the documentation.

Each of the modules is described in a "Design Specification" section of the document. Additionally, for those routines which are on the "critical-path" with regard to processing accuracy, time, and/or storage requirements, "Performance Specifications" are included. This is a vital step often overlooked in system design and is to be commended. However, we have no way of determining whether or not the

hardware and software implementation allows these specifications to be met in actual practice, and can only assume that this will be the case.

With regard to the System Monitor and Control Modules, there is little to be said, as these are highly hardware dependent, and, at the same time, should be almost completely transparent to the FLIT/MPS user - he should be unaware of their existence. It is assumed that these modules handle the inevitable hardware failures in a "graceful" manner; this means full automatic recovery in the best of cases, and in any case, to provide a convenient restart procedure along with informative diagnostic capability.

The Data Entry and Display category is perhaps the most critical with respect to both design and performance of the system. This is because MPS is primarily an on-line, interactive, man-machine system. It is vital that this interface put as few burdens on the operator as possible, and, according to the specifications, this is indeed the case so long as the operator is skilled.

What is not clear, however, is the response of the system to well intentioned but inadvertent errors on the part

of the operator. In a well-designed interactive system, the operator will work in close "rapport" with the input and display devices, and, working rapidly, will often make minor mistakes which are "almost" right, but which, in a poorly designed system, can lead to disastrous results. An example will illustrate. The operator must, of course, be given a "clear the decks and start all over" capability. The interactive system must make sure that this command is really meant by the operator, and not just an inadvertent action - otherwise, much work may be lost, with great operator frustration. Placement of the key on the keyboard (or virtual key on a light-pen/CRT) should isolate this function as much as possible, of course; but the software must also respond with a "Do you really want to do that" indication in such a situation, if a smooth man-machine interaction is to be achieved. A general rule is that, on any error, the operator should be able to "back up" and try again, and that the "backing-up" should be limited, whenever possible, to the point immediately preceding the error condition.

Errors of this kind often arise when an interactive system operates in several "modes", with nearly identical operator actions having dissimilar effects in each of these modes. For smooth interaction, therefore, it is essential that: 1) the number of modes be held to a minimum; 2) that the operator be clearly aware of the current system mode; 3) the operator be able to change modes at will; and 4) that

identical operators have identical or corresponding actions in each mode whenever possible, without ambiguity.

The above state of affairs, however vital, is not easy to achieve, and cannot be determined by an examination of the software design and performance specifications, but only by actual on-line experience. It is hoped that the project development schedule allows for the incorporation of these features during systems checkout and acceptance testing.

With regard to the Data Entry category, the following specifics are felt to be relevant:

- While both the working and system velocity profiles may be displayed simultaneously, it is unclear whether or not a similar capability exists to display the shallow (0-200 feet, say) portion of the profile on an expanded scale simultaneously with the complete profile. The greatest "structure" is often in this shallow portion, and, a linear scale to full bottom depth, is quite inappropriate.
- What is the effect on the display when the allowable (vertical) density of svp points is exceeded?
- Are provisions to be made for metric as well as English units?

- Is any interface with a library of previously cataloged SVP data possible? Must all data be entered via the terminal by the operator? Are there provisions for storing this data on other than a transitory basis?
- Is it possible to interrupt the SVP processing to examine and change table update parameters and return to the same point in SVP processing?
- Is it possible to have incompatible SVP and table update data? (E.g., bottom depth, deep ocean temperature, etc.)
- Are alerts displayed only in a certain display mode, or is a separate hardware display unit used?
- Must the source and receiver depths used in the ray-tracing modules be inserted as explicit points in the profile? Is this done automatically? If so, how is the interpolation made? If not, how is the operator requested to do so?
- Are future provisions envisioned which will allow automatic corrections to profile depths and velocities to account for spherical earth geometries?

A final point can only be determined by operational evaluation, namely, do the specified system functions provide

an adequate base, or must more functions be implemented in response to operator feedback after initial system operation. Again, it is to be hoped that development time is available for this if necessary.

The third category of modules in the MPS system are those implementing the Ray Tracing and Display Functions. It is here that the greatest opportunity for compatibility or incompatibility with other systems and the state-of-the-art exists. It can be stated at the outset that the ray-tracing physics employed does accurately implement Snell's Law for a layered medium, using standard equations and techniques. The relation between ray tracing and accurate estimation of transmission loss is quite another matter however -- witness the widely differing approaches of the many available ray-tracing transmission loss models. And, in a similar manner, the relationship of transmission loss estimates to performance prediction for active and passive detection systems presents a complex problem in modeling techniques. A separate, detailed evaluation of this area of MPS remains to be made; however, a number of comments follow, which are based on preliminary examination of the specifications. These are based on a comparison of the functions of MPS with those of FACT, the Navy Interim standard transmission loss model for a single-profile, flat-bottom ocean environment.

- Acoustic transmission loss is estimated along a single ray path only; the effects of multiple

ray paths from source to receiver are ignored. There seems to be no provision for combining arrivals over a range of ray angles to obtain an overall transmission loss estimate. This seems to be a significant oversight in light of the "variable beam" capability which presumably is useful for matching sonar receiver beam widths.

- This single-path transmission loss is compared with a single Figure-of-Merit for a sonar system. It is unclear how this Figure-of-Merit is input (i.e., what drives the related shaft encoder), and how this varies with platform speed (self-noise) and background noise, which itself is a function of the transmission loss in the medium being modeled. The distinction between active and passive systems is unclear.
- Because of the effects introduced by a linearly-segmented profile as opposed to a smooth sound-velocity profile, the process used to select the rays to be traced is critical. The segmented profile introduces false caustics into certain rays, and these must be avoided to prevent the expression used for transmission loss from becoming indeterminate. Similarly, the rays defining true caustics must be selected and retained.

- All transmission loss estimation formulas ignore the effects of smooth and cusped caustic fields; it is usually in these regions where the most "interesting" transmission loss effects occur.
- No provision has been made for including coherency effects for source and/or receiver depths close to the surface; these geometries lead to two or four nearly parallel transmission paths along which interference effects become significant.
- The effects of frequency are confined to surface, bottom, and volume absorbtion effects.
- No treatment for half-channel and/or axis-to-axis transmission has been included; these cases require the combination of many paths from the source to receiver for accurate transmission loss estimation.
- No provision for incorporating low-frequency cut-off effects has been included.
- No provision for treatment of surface-duct transmission has been included.
- The only transmission-loss display is the two-level brightness along a ray path indicating whether or not the Figure-of-Merit has been exceeded. In view of the way in which transmission loss is estimated, this indeed may be

appropriate. It would seem more useful, however, to display a complete transmission loss graph as a function of range, with a horizontal line overlaid to indicate the Figure-of-Merit.

It should be noted that nearly all of the above comments relate to the incorporation of additional sophistication into the process of going from simple ray-tracing to transmission loss estimation, and that all can require significant additional program development. This, in turn, will make additional demands on the implementing hardware, requiring more computation time and core storage. Since no information whatever has been made available as to the constraints on these resources imposed by the available hardware, and by the response-time characteristics which must be achieved, these may well be the limiting factors in determining the accuracy of system performance estimations.

Of the final category of modules, Functional Evaluation, only a few comments are in order.

- The relationship of the formulas for profile temperature and sonic velocity to those of the widely-used Wilson's equation has not been examined; it is not known if any significant differences exist.

- The relationship of the expressions for bottom-bounce losses to those of the widely-used FNWC tables and formulas has not been examined; again, it is unknown if any significant differences exist.
- The formulas used for surface-reflection estimation introduce a discontinuity of about .3 dB; it has not been determined if this figure is significant.

In summary, a number of comments have been made as a result of a review, from a systems analysis and programming viewpoint, of the Design and Performance Specifications for the MPS Ray Path Trace Submode of FLIT. As in any highly interactive system, definitive evaluation must be based on observations of the actual performance of the system in its intended environment, with special emphasis on the man-machine interface. This clearly has not been possible in the present case. Similarly, a definitive evaluation of the applicability of the physical model employed depends critically on the uses which the model results are to serve. Again, this determination can be made only by evaluation of the system by persons with experience in acoustic modeling situations.

The foregoing considerations lead us to conclude that unless the previously referenced review of the physics of the FLIT system indicates the need for new developments (directed,

for example, at enhancing the transmission loss estimation) no change to the current FLIT system would seem to be either necessary or advisable at this time, certainly not as a result of any programmatic implementation considerations.

### **III. OBJECTIVES OF SIMAS**

The SIMAS -- Sonar In-Situ Mode Assessment System -- model is a set of programs designed to automate the sonar watch supervisor's task by estimating acoustic path availability and detection ranges, and by providing recommended equipment settings, primarily for the SQS-26 sonar. The system was originally implemented at the Naval Underwater Systems Center (NUSC), Newport, Rhode Island. Additional development of SIMAS has been performed at the Naval Electronics Laboratory Center (NELC), San Diego, California.

As part of an overall task of investigating the degree to which commonality of conceptual approach and compatibility could be achieved among a number of existing at-sea performance prediction systems, Ocean Data Systems, Inc. (ODSI) has attempted to determine the feasibility of providing onboard SIMAS capability for fleet operations in a reasonably short time frame (6 months), and to determine how this effort could best be undertaken. A primary objective has been to insure that such a capability employs the most accurate methods of computation, consistent with the constraints of existing computational resources, and uses the best data available, thereby achieving a step towards further standardization of Navy acoustic performance systems.

At a very broad level of detail, SIMAS can be considered as consisting of three separate but interrelated components:

- Environment. This component combines in-situ bathythermographic data with historical data as the basis for generating a sound-velocity profile from surface to bottom.
- Range Prediction. On the basis of the environmental profile, signal excess values are computed as a function of range for direct-path transmission, and as a function of two-way travel time for bottom-bounce and convergence zone modes.
- Equipment Optimization. Using the computed signal excess values, the applicability and utility are estimated for each transmission mode, and, where practical, equipment switch settings are determined which will give the best performance from the sonar system being used.

It should be noted that the first two components must, in general terms, be provided for any acoustic performance estimation system, and that it is these areas that commonality with other systems is most likely to be achieved. For example, the ICAPS system developed by NAVOCEANO currently provides common environmental processes for at least three acoustic models, and one of these, SHARPS, computes signal excess values as a step in estimating expected detection ranges for sonar systems.

Only the third component, that which provides sonar "knob settings", is peculiarly the function of the SIMAS system.

In order to provide an at-sea SIMAS capability at the earliest possible date, some means must be found to integrate the existing on-shore programs into existing on-board computer systems, while balancing the conflicting requirements of minimum development time, maximum compatibility and commonality, and constraints imposed by programming language and hardware computational resources.

Subsequent sections of this report discuss the currently available versions of SIMAS and the at-sea operating environment, and the prospects for timely introduction of an operational SIMAS model to the fleet.

#### **IV. CURRENT STATUS OF SIMAS**

There currently exist three separate versions of SIMAS which provide the basic functions outlined in Section I. For convenience, the remainder of this report will refer to these by reference to the primary computer system on which they were implemented. It should be kept in mind, however, that this distinction does not necessarily reflect their most important differences, as the following brief descriptions will make clear:

1108. This version of SIMAS was developed at NUSC. The program is written entirely in FORTRAN, and can thus be modified with relative ease to work with and take advantage of commonality and/or overlap with other acoustic prediction systems modelled in FORTRAN. Additionally, the program can be adapted to run on hardware configurations which have sufficient capacity to support a FORTRAN compiler. This freedom is not without limitations, however, as the resulting running time may increase exorbitantly if the conversion is to a mini-computer in which floating point arithmetic is performed in software rather than in hardware.

PDP-11. This mini-computer version of SIMAS was also produced by NUSC, and adds to the basic functions of the 1108 version the capability to monitor background acoustic

noise, on an in-situ basis. The results are compared with predicted noise values to facilitate decisions regarding the validity of the detection forecasts. This capability, not readily if at all obtainable in a standard FORTRAN environment, is felt essential to high-reliability SIMAS operation and should ultimately be incorporated in any operational version of SIMAS.

Q-20. The NELC version of SIMAS was developed with the explicit goal of operation within the Naval Tactical Data System (NTDS) environment. It was produced from the 1108 version by direct conversion to 642B (Q-20) machine language, replacing floating with fixed point arithmetic. To satisfy the requirements imposed by the NTDS systems, it was necessary to introduce transfers to the NTDS operating system monitor at intervals not exceeding 35 milliseconds. Nevertheless, this version is not directly compatible with at-sea NTDS hardware: The NELC system is equipped with a prototype mass memory instead of the operational Dynamic Module Replacement.

The three versions of SIMAS identified above are ostensibly identical in their functional capability and performance; the sole exception being that neither the 1108 nor the Q-20 versions provide the background noise monitoring feature available through the PDP-11 version. Additional incompatibilities may arise in the case of the Q-20 version: In the limited time imposed by available funding, NELC was only able to verify the operation of its version against the single test case with data and

expected intermediate and final results supplied by NUSC. Considerably more testing would be required to ensure the validity of the internal scaling employed and computational accuracy of the functional subroutines over the full range of expected input values.

None of the three systems are currently operational in the sense of being regularly executed on a routine basis for the purpose of acoustic prediction in a "live" environment. Any or all, however, are potential candidates for providing such an operational capability in the near future.

### COMPATIBILITY WITH EXISTING SYSTEMS

In order to maintain compatibility with existing at-sea acoustic models - in particular with ICAPS (Integrated Carrier Acoustic Prediction System) - common functions should ideally be performed by the same, or in any case identical, program segments. Comparing SIMAS with the models combined in ICAPS, this potential exists with regard to both the environmental and range prediction sections. Primarily for historical reasons, each of the ICAPS models, written in FORTRAN, accepts as input a complete profile consisting of depth-temperature-salinity triplets, and uses identical sub-programs to convert these to a sound velocity profile by the application of Wilson's equation. By the same means, SIMAS could accept identical inputs from the environmental section of ICAPS and likewise apply Wilson's equation. As ICAPS includes a procedure for referencing a large data file of historical profile information, this would result in a significant enhancement of the SIMAS environmental section. For the 1108 FORTRAN version, the modification would be quite easy; however, the difficulties which might be encountered with the PDP-11 and Q-20 versions cannot be immediately determined.

The situation is much less clear with respect to the signal excess - range prediction sections, particularly in light of the relationship of this section with the equipment optimization section in SIMAS. The active performance section of ICAPS is SHARPS (Ship-Helicopter Acoustic Range Prediction System),

(again written in FORTRAN). The signal excess sections of SHARPS and SIMAS differ in two very significant ways:

First, the SIMAS optimization capability deals with bottom bounce and convergence zone modes and investigates the signal excess function for each of the eight beam patterns. The beam patterns are an essential element of the optimization process. In calculating signal excess, however, SHARPS uses analytical approximation in lieu of representing discrete beam patterns.

Second, the signal excess function in SIMAS is evaluated at 0.5 second intervals of the two-way travel time. SHARPS, on the other hand, evaluates the signal excess function on the basis of starting angle selections. A minimum and a maximum starting angle are determined and the angle increment for successive signal excess evaluations are computed as a fixed division of this angular range. If the horizontal range increment resulting from two successive starting angles increases beyond some threshold, the angular increment is reduced. The significant effect of this technique is that successive evaluations of the signal excess function do not represent linear increments in any independent variable, thereby resulting in a more complex determination of the integral of the signal excess function over a fixed length but moving "window" than was previously the case.

In the active area, these two considerations dominate, making it unlikely that compatibility can be easily achieved; the considerations of FORTRAN versus machine language remain as before. In the ideal situation, of course, identical program modules would be called by both SHARPS and SIMAS to compute the signal excess values as required. This however, would involve an extensive development effort, and is not applicable to the present discussion.

## VI. PROSPECTS FOR AT-SEA SIMAS

It is clear that the most desirable operational mode for SIMAS would be as an integral component of the Naval Tactical Data System (NTDS). This integration is subject to a number of constraints, imposed both by hardware considerations and by the standard NTDS administrative procedures.

Originally, NTDS was designed as a single processor system, with each computer complex containing 32,000 words of core memory, 30 bits in length, with no hardware floating point capability. However, as demands on the NTDS grew, additional processors were added to meet these needs, so that ships with NTDS aboard now can have anywhere from one to four processors linked together. The overhead associated with linking computers grows as their number increases, however, and the law of diminishing returns sets four processors as a practical upper limit to this mode of operation. Additional capability is achieved by the addition of the Dynamic Memory Replacement (DMR) feature which permits program segments of up to 20K in length to be kept on magnetic tape and automatically called into core for execution as required. DMR is only available in NTDS installations having two or more processors.

For any new program to become an official part of NTDS, therefore, it must be designed to work with the DMR feature, at least until late in calendar year 1975, at which time a solid-state mass memory will start to appear in the fleet.

Administrative constraints are imposed by the Fleet Combat Directions Systems Support Activity (FCDSSA). This organization has the responsibility for the installation and maintenance of all programs that are to be part of NTDS. Before any program will be accepted by FCDSSA for distribution to the fleet, it must be supported by very extensive documentation, written to FCDSSA standards. In addition, the program must be written in either the CS-1 or CMS-2 languages for the Q-20 computer. Once a program has been accepted, it is tailored by FCDSSA for each individual ship on which it is to operate, in order to account for hardware differences both within an NTDS facility itself (processor configurations, available input-output equipment, display devices, etc.) and elsewhere on the ship (sensors, weapons systems, etc.). FCDSSA thus has a continual program of preparing systems for new ships, and for updating existing on-board systems to incorporate new capabilities and accommodate equipment changes. This involves an extensive scheduling process to mesh with ship availability and hardware installation dates, and thus there is a nominal lead time of about 18 month from the time a program is accepted by FCDSSA to the first appearance of the program in the fleet.

In order for SIMAS to become operational under NTDS, therefore, the following steps would be necessary: 1) Additional testing and verification; 2) modification of this version to accomodate the DMR hardware feature; 3) the preparation of the system documentation, and 4) the acceptance, tailoring, and

dissemination of the program by FCDSSA. While the first three of these steps could proceed in parallel to at least some degree, it is estimated that 24 to 30 months would elapse if this mode of operation were to be implemented, and alternate approaches must be considered.

One possible modification of the above approach would be to operate SIMAS on the Q-20/642B hardware of NTDS, but divorced from NTDS/FCDSSA operations; i.e., in a stand-alone mode. This would require the removal of one computer from the NTDS configuration for exclusive use by SIMAS. In order to do this, NTDS itself must be shut down to make the initial change-over, restarted to work in a mode of degraded capability, shut down again when SIMAS is no longer required, and, finally restarted in the fully operational mode. Theoretically, each shutdown and restart of NTDS should take anywhere from one to three minutes. However, NTDS maintains a rather large data base that is continually being updated; this data base is lost on system shutdown, and, after restart, approximately 15 minutes is required to reconstitute the complete data base. When the effects of this degradation are compounded with the reduced capability of a system with a central processor removed, it is clear that the operation of NTDS would be seriously impaired, and it appears unlikely that shipboard personnel would elect to execute SIMAS under such circumstances.

Apart from these considerations, Q-20 program verification must be accomplished; documentation (though not as extensive as required by FCDSSA) must be prepared; and some group other than FCDSSA found to assume responsibility for on-board installation and maintenance of the model. It is estimated that at least 12-15 months would be required if this mode of operation were to be adopted.

A third approach which might be pursued would involve the operation of SIMAS as a part of the ICAPS (Q-20/642 hardware) system. This would restrict the program to carrier operation, as only those ships will have this type of instllation, but perhaps this environment would provide valuable information as to the operational utility of SIMAS. Since the Q-20 version was not designed to operate under the SYMON monitor, and since other ICAPS programs are written in FORTRAN, it would be appropriate to modify the 1108 (FORTRAN) version of SIMAS for this application, and to take advantage of the ICAPS environmental section as well. Other considerations for this mode are similar to those of the NTDS stand-alone mode. This approach could be implemented in about 4 months.

The only other alternative with any significant probability of success is that of direct adoption of the PDP-11 version for stand-alone shipboard use. This approach has the obvious

advantage of starting with software which already incorporates background noise monitoring capability and which need not be modified for compatibility with any existing monitor program. On the other hand, however, it would require the addition of new non-standard mini-computer and interface equipment to the existing shipboard environment. The obstacles to be overcome here are difficult to estimate, but would probably be severe; even if authorization could be obtained quickly, procurement and other procedural delays would probably stretch the development time to as long as several years.

It is to be noted that only the last of the above approaches provides the background noise monitoring feature. The motivation for implementation of this feature was largely that of a feasibility study. Noise monitoring was only tested in a small number of cases and only in bottom bounce mode. Before this feature could be considered operational, even on the PDP-11, there would have to be a great deal more testing. In addition, installation of this capability in any shipboard situation would require selection and procurement of the necessary hardware to capture and convert the noise signals for use by the computer. Furthermore, to incorporate this feature in any but the PDP-11 versions of SIMAS, it would be necessary to write the noise monitoring program in the appropriate language for execution under the host computer's operating system. Even though the

PDP-11 version could be used as a guide in this operation, writing and fully testing this feature would probably require 6 months, at least three of which would have to be after the appropriate analog-to-digital conversion hardware was available.

In summary, then, it appears that within NTDS there are in fact no alternatives which would permit the attainment of an on-board SIMAS capability in less than a year, and even under the best of circumstances would result in inconvenient, awkward, or otherwise unacceptable modes of operation. Only if an extra Q-20 computer is available outside of the NTDS system can an at-sea SIMAS capability be achieved within 6 months. It must be emphasized that this fact in no way reflects on the technical capabilities either of SIMAS itself or of its developers, but rather is to be expected whenever an attempt is made to merge a new computer-based capability into an existing environment which did not foresee the addition of such capability in the early design stages. For the future, such difficulties can be avoided only by planning now for direct implementation of the features of SIMAS into the new digital sonar systems which will be appearing in the fleet in the next five to ten years.

APPENDIX A

AESD MEMORANDUM OF 20 SEPTEMBER 1973  
REVIEWING THE  
FLIT PROGRAM



DEPARTMENT OF THE NAVY  
OFFICE OF NAVAL RESEARCH  
ACOUSTIC ENVIRONMENTAL SUPPORT DETACHMENT  
ARLINGTON, VIRGINIA 22217

IN REPLY REFER TO  
AESD:PRT:dod  
20 September 1973

MEMORANDUM FOR MR. FRED BRUMBAUGH, PMS-3026

Subj: FLIT Program

1. On Thursday, 19 July, I visited Raytheon with Mr. C. W. Spofford of my staff and Dr. Morenoff and Mr. Baker of Ocean Data Systems, Inc. The purpose of the visit was to review both the physics and the programmatic implementation of the FLIT model. At Raytheon we met with Mr. Tom Russell and Mr. Jerry Bradshaw of Raytheon; Mr. Dick D'Urso of NUSC Newport, and Mr. Barry Chapmar from NAVSHIPS.
2. We were not briefed on the purpose of the FLIT system. We were told that it was too highly classified; the discussions were confined to the ray-tracing sub-mode of the system.
3. Apparently, the ray-trace propagation loss model developed by Mr. William Barry of NUSC Newport had been provided to Raytheon for implementation on a 16-bit computer. Raytheon had essentially no freedom in the selection of physics to be implemented, rather their task was to implement the highest possible speed ray-trace in an interactive mode on this mini-computer. The system as we saw it demonstrated accepts as input from the operator either the sound speed profile from the surface to the bottom or a given BT profile. If given a sound speed profile, the operator can display the given profile on a CRT display and then make modification to this profile until the displayed profile meets with the operators satisfaction. If given a BT profile, which only extends to rather shallow depth, the program assumes the gradient of temperature to be a constant until it reaches the bottom temperature and then isothermal to the bottom. It then assumes at present a salinity of 35 ppt and uses Leroy's equation for the computation of sound speed. With the sound speed profile established, the system computes a fan of rays for particular parameters of source depth, maximum range, angle of tilt and beam width which are all under operator control. The ray tracing is very high speed, and the display almost continuously changes as the operator changes one of these four input specifications. At some future point in time, the system will also compute the propagation loss along each of the rays, and display the rays on the CRT display in a two-tone brightness display. The rays will be brighter when the loss along the ray does not exceed an operator controlled figure of merit, and less bright after that figure of merit is exceeded. This binary representation of propagation loss is less than optimum in that it essentially displays only the

fifty percent probability detection contour. With the given display facilities, it should be possible to present contours in range and depth of propagation loss:— Since the algorithms for the computation of transmission loss along an individual ray were neither developed by the Raytheon team nor implemented yet in the FLIT system, no detailed discussion of these techniques was appropriate. One minor point worthy of comment, however, is that the loss at the bottom, as it will be implemented, is at present independent of frequency.

4. From a software point of view, the system has been extremely well implemented. Some sophisticated programming, as well as good solid numerical analysis has been done and very effective use has been made of software people who are also well aware of hardware capabilities. Extremely effective use has been made of existing display hardware capability. The sophisticated numerical analysis which has been done might be transferable to another configuration, but the detailed programming probably cannot. Implementation on another machine or for a different display system could well take an equivalent or greater amount of development time. Present implementation proves, once again, that special purpose highly constrained systems are much more efficient than any general purpose system, but they are hard to change, expensive to build, and not easily transferable. Software maintainence would be difficult to perform outside the development group at Raytheon. For example, even simple changes like changing the form of the bottom loss equations to be frequency dependent could not be done in an operating environment.

5. In summary it is considered that the group at Raytheon has done an outstanding job of implementing the specified model on an existing mini-computer and specialized display system. Any more detailed critique of the physics of the transmission loss package incorporated in the FLIT system must be done in conjunction with the model developers at NUSC Newport.

*P. R. Tatro*  
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Copy to:  
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Dr. Ed Morenoff, ODSI

